9. Self Generation

The combination of a nearly constant electrical load and the need for a high degree of reliability make large data centers well suited for self generation. To reduce first costs, self generation equipment should replace the backup generator system. It provides both an alternative to grid power and waste heat that can be used to meet nearby heating needs or harvested to cool the data center through absorption or adsorption chiller technologies. In some situations, the surplus and redundant capacity of the self generation plant can be operated to sell power back to the grid, offsetting the generation plant capital cost.

Principles

• Self generation can improve efficiency by allowing the capture and use of waste heat.

• Waste heat can be used to supply cooling required by the data center through the use of absorption or adsorption chillers, reducing chilled water plant energy costs by well over 50%.

• High reliability generation systems can be sized and designed to be the primary power source while utilizing the grid for backup, thereby eliminating the need for emergency generators and, in some cases, even uninterruptible power supply (UPS) systems.

Approach

Data centers typically require sufficient emergency generation capacity on-site to support all the data center equipment and its infrastructure. Making this generator capacity the primary source of power for the facility—using efficient technologies—provides numerous benefits. The ideal primary power supply for a data center is an on-site generation system with short and simple distribution paths, and double redundancy at a minimum with waste heat recovered and used to power the cooling system.

Using waste heat for cooling can increase site efficiency and improve reliability for large data centers; in most situations, the use of waste heat is required to make site generation financially attractive. While large data centers have little need for space heating, waste heat from onsite co-generation can drive thermally based cooling systems. This strategy reduces the overall electrical energy requirements of the mechanical system by eliminating electricity use from the thermal component, leaving only the electricity requirements of the auxiliary pumps and cooling tower plant.

Absorbers use low-grade waste heat to thermally compress the chiller vapor in lieu of the mechanical compression used by conventional chillers. Rather than refrigerant and a compressor, a desiccant that absorbs and releases water, in the process absorbing and releasing heat, is used to remove heat from the chilled water loop and reject it to the condenser loop. The electrically driven compressor is replaced by a heat driven dessicant cycle. Single stage, lithium bromide dessicant based chillers are capable of using the low grade waste heat that can be recovered from common onsite power generation options including microturbines, fuel cells, and natural gas reciprocating engines. Although absorption chillers have low Coefficient Of Performance (COP) ratings compared to mechanical chillers, utilizing 'free' waste heat from a generating plant to drive them increases the overall system efficiency. Absorbers are a very mature technology available from several major manufacturers, although they are less efficient than adsorbers in converting low grade (low temperature) waste heat to cooling.

A potentially more efficient thermally driven technology that has begun making inroads in the domestic market is the adsorber chiller. An adsorber is a desiccant-based cooling system that uses waste heat to regenerate the desiccant and cooling towers to dissipate the removed heat. An adsorption chiller minimizes its auxiliary loads by eliminating the absorbent pump and decreasing the run times of the vacuum and refrigerant pumps, thus further limiting the electricity requirements while maintaining a similar thermal COP. The silica gel based system uses water as the refrigerant and is able to use lower temperature waste heat than a lithium bromide based absorption chiller. While adsorption chillers have been in production for about 20 years, they have only recently been introduced on the American market.

An appropriate purpose-designed self generation system could eliminate the need for a UPS system, with the attendant first cost and efficiency implications. While some companies have offered such high reliability systems, they have not been widely implemented as of this writing. However, with the proper redundancy and design, data center facilities can eliminate UPS systems and achieve significant efficiency benefits at reasonable cost. The current market offerings for high reliability power should be evaluated for new data centers.

The recommended system would typically be sized to cover the full site load (as allowed by local utility and codes) and connected to the grid to ensure reliability and to improve payback. The grid would serve as the backup to the self-generation plant. The key to successful connection with the utility is two very fast circuit breakers or static switches on each generating bus to quickly disconnect the on-site generator and prevent any possible damage associated with reverse fault flows during times of grid failure, when the on-site generator must operate in an "island" mode.

Any self-generation system would need to be designed carefully to meet all local codes and requirements, including air emission limits. Storage of backup fuel for natural gas systems can also be a code and technical challenge, with propane and dual-fuel capable generators often used to create an onsite emergency fuel storage solution.

Frequently, self-generation systems are sized to only supply a baseline quantity of power, offering the benefits of waste heat reclamation at a reduced first cost. However, depending on the specific generation equipment used, there can be a significant delay between operation in a baseline mode with the utility grid always used to 'top up' to the actual required load, and operation in an island mode, with standard backup generators or load shedding used in place of the grid. It is the transfer time from operating in a grid connected mode to operating on the generator plant alone that often necessitates the continued installation of UPS systems.

Ideally, an important benefit of interconnection with the utility would be that unused generating capacity could be sold back onto the grid. This would offer the flexibility to keep generators running at full load, thus making them optimally efficient (globally more fossil fuel efficient). The export of spare power could be an additional revenue source, shortening the payback period of the total investment. While the economic benefits of selling power back are considerable, the combination of power export and high-reliability operation is challenging. A cooperative distribution utility and careful design is required to achieve the level of reliability required by data center facilities.

Resources

- *Data Processing and Electronic Areas*, Chapter 17, ASHRAE HVAC Applications, 2003.

- Casestudy: http://www.energyvortex.com/files/MissionPlasticsCaseStudy.pdf

References

1) Assuming 40% electrical efficiency natural gas generator with 70% of waste heat recovered and used to drive a chiller with a 0.7 CUP (at $.014/kwh and $1.00/therm).

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